KLOOFENDAL NATURE RESERVE

Part 2:

ECOLOGICAL MANAGEMENT PLAN

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31 December 2014

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CHAPTER 1

INTRODUCTION

The primary objective of the Kloofendal Nature Reserve (KDNR) should be to create and conserve a natural environment that is rich in biodiversity and is managed and maintained according to sound ecological principles. Reserve management should:

- strive to maintain and/or restore the integrity and diversity of the natural habitats and their associated biota;
- enable viable and sustainable wildlife conservation and utilisation based on sound veld management and wildlife management principles; and
- allow human use of the area consistent with the first two goals.

Although the objectives are to promote the natural functioning of the ecosystem, this is not always possible. The reserve is a small, fenced unit and it is sometimes necessary to intervene especially during outbreaks of disease and/or severe drought and when overpopulation of wildlife occurs. Thus, recognising the fact that the system cannot function as an entirely naturally regulated ecological system, the policy should be to apply management interventions to achieve the management objectives of the KDNR.

Veld and wildlife management is a dynamic process and should follow changes in climate and veld condition. The wildlife numbers should be purposefully increased or decreased depending on the rainfall and veld condition. Removing animals during dry years limits mortalities and prevents the overutilisation of the veld.

CHAPTER 2

ECOLOGICAL FILING SYSTEM FOR THE OFFICE OF THE MANAGER

2.1 Introduction

An ecological filing system provides for the storing and retrieving of ecological information and aids in the compiling and reviewing of the management plan. This system is best used on a personal computer, but hard copies remain indispensable. A file is allocated for each key objective of the operational management plan. A Geographic Information System (GIS) should be used whenever there is a spatial component.

The following is an example of the elements that an ecological filing system should contain:

2.2 Historical overview and source document

Archive material and historical data as well as maps and dates of land acquisition indicating registered farm names and surface area (ha) of each. Copies of all permits and their numbers, e.g. exemption permit from GDARD should be filed here.

2.3 Climate

Rainfall should be diligently recorded. As a minimum requirement a rain meter should be erected at the office/amphitheatre complex and rainfall data should be collected after each rainfall event. If this meter can not be visited after each rainfall event a few drops of oil could be put into the meter and rainfall can be measured twice weekly.

Long and short-term trends in rainfall should be analysed and these data should influence decisions regarding several aspects of biodiversity as well as the wildlife management programme. Reports on interpretations and projections about rainfall should be included in the climate file.

2.4 Geology, land types and soils

All maps or information pertaining to geology and soils should be kept here. The geology and soil types have a direct influence on the vegetation and often on the palatability of the plants growing there. Sensitive areas, such as localities that are prone to erosion, have to be mapped and the maps filed.

2.5 Cultural heritage

Locality maps and descriptions of all heritage and archaeoplogical sites, e.g. mines, kraals, ruins, old graves and dwellings older than 60 years, should be documented in this file.

2.6 Water provision

Maps indicating the distribution and permanence of watering points should be compiled and filed. If watering point are periodically closed then these periods of closure should be documented. All water analysis reports and the incidence of nutrient and mineral deficiencies are to be filed.

2.7 Infrastructure

Maintenance and regular patrols of the fences and roads should be undertaken. The findings of each patrol should be documented and filed.

2.8 Flora and vegetation

Maps, reports and other publications on the vegetation and veld condition are essential components of wildlife management and should be kept for future reference.

Checklists:

- A checklist of all plant species and separate lists of Red Data species (with localities and population sizes) should be compiled.

Vegetation monitoring:

- A complete description of monitoring methodology and map of sample sites (and GPS localities) should be prepared and filed.
- All report on the vegetation monitoring should be filed.
- Monitoring should also be done on burnt areas.

Grass and forb strata:

- A complete description of monitoring methodology and map of sample sites (and GPS localities) should be prepared.
- Reports on veld condition, recommendations, species composition trends and changes should all be filed.
- Report on impacts of fire should be kept.

Woody component:

- A complete description of monitoring methodology and map of sample sites (and GPS localities) should be prepared.
- Reports on monitoring, recommendations, species composition trends and changes in structure should all be filed.
- Reports on impact of fire on the woody vegetation should be filed.
- Reports on bush encroachment and its control should be kept.

Photo-monitoring of vegetation structure:

- Develop a historical photo bank with maps of reference points (and GPS localities).
- Any reports and recommendations pertaining to the photos should be filed.
- A complete description of monitoring methods should be prepared.
- Hard copies as well as electronic copies of the photos should be kept.

Biomass assessment:

- A complete description of monitoring methodology and map of sample sites (and GPS localities) should be prepared.
- Both the woody component and the grass layer could be surveyed for biomass.
- Reports on long and short-term trends should be compiled.

Fire programme:

- A fire policy document should be set up.
- The occurrence of all fires on KDNR should be recorded.
- The area burned should be indicated on a map together with the date and weather conditions at the time of the fire, fire intensity and the reasons why the fire occurred should all be noted.

Veld reclamation and erosion control:

- Maps and photos where veld reclamation or erosion control is being implemented should be included in this file.
- Reports on the progress and recommendations should be filed.

2.9 Fauna

Checklists:

- A checklist of all faunal species and separate lists of Red Data species (localities and population sizes) should be compiled.

Wildlife information:

- Compile a collection of type-specific information and publications for reference purposes.

Wildlife history;

- Compile a wildlife register on dates and numbers of introductions and off-takes with information on origin of introduced wildlife and genetic information for a genetic data bank (if relevant).
- Record sex ratios, all births and deaths and calculate population growth rates.

Wildlife counts:

- Compile a history of counts and any evaluation reports.
- Methods and techniques of counting should be comprehensively described.

- Trends in animal numbers should be analysed and recommendations made.
- A reliable animal census should be done annually or at least every second year or before animals are removed for auction. Helicopter counts are the most popular method of counting animals if numbers cannot be established with confidence by other means. Harvesting rates are calculated from annual population growth rates.

Wildlife recommendations:

- Determine grazing and browsing capacity estimates from veld condition surveys.
- Establish the grazing spectrum and feeder ratios.
- Document all wildlife reductions.

Wildlife distribution:

- Compile maps of wildlife distribution (habitat use) based on the vegetation types.
- Establish short- and long-term trends in population sizes.
- Provide a description of survey techniques and methods with management recommendations.

Wildlife physical condition and age structures:

- Any information on population composition, social structure, sex ratios and growth rates; mortalities, diseases, parasites and post-mortem reports and recommendations can be filed.

Birds:

- Document any management recommendations for the conservation of specific species occurring on the property.
- Document participation in organised events.

Rare animals:

- Should klipspringer and/or oribi be introduced, populations should be carefully monitored.
- Survey and monitoring techniques should be described
- All recommendations should be documented.

Supplementary feeding:

- All details regarding a mineral lick and supplementary feeding programme, e.g. amount and dates supplied, and points of supply should be documented

2.10 Alien species management

Alien flora management:

- Compile a list of all alien flora.
- Prioritise alien species in terms of threat and control.
- Prioritise areas or plant communities for control of alien invasive plant species.

- Document all actions to eradicate or control invasive species.
- Provide details on methods used for control in each specific area (mechanical, chemical or biological) and type of chemicals used.
- Compile maps and provide photos of where these actions were implemented.
- All monitoring reports on the success or failure of control actions should be documented.
- Work programmes and schedules should be filed.
- A database should be developed on mechanical, chemical, and biological control measures for the different species on the reserve.
- Document all expenses on alien plant control actions.

2.11 Control of bush encroachment

- Compile a list of indigenous encroaching species on KDNR.
- Prioritise encroaching species in terms of threat and control.
- Prioritise areas or plant communities for control of bush encroachment.
- Provide details on methods used for control in each specific area (mechanical, chemical or biological) and type of herbicide used.
- Document all actions to control bush encroachment.
- Compile maps and provide photos of where these actions were implemented.
- All monitoring reports on the success or failure of control actions should be documented.
- Work programmes and schedules should be filed.
- A database should be developed on mechanical and chemical control measures for the different species on the reserve.
- Document all expenses on bush encroachment.

2.12 Ecological projects

- Identify aspects in need of research.
- Compile a list of all projects conducted on the KDNR by students or staff. If possible, file hard copies of all reports.
- File all management reports with regard to specific taxa (fauna and flora).

2.13 Master plan: policy, procedures and proceedings

- All aspects relating to the list of contents of the ecological management plan (EMP), policy and procedures regarding the master plan and all management agreements and contracts are to be filed here.
- Minutes from management meetings and work schedules and results from strategic management planning exercises to be filed here as well.
- The Ecological Management Plan (EMP) should be updated annually.

2.14 General

References and contact details of the Friends of Kloofendal, contractors, consulting ecologists, advisors, students, staff and workforce should be compiled.

CHAPTER 3

INFRASTRUCTURE

3.1 Fences and gates

Sections of the boundary of KDNR are currently fenced with an approximately 2.1 m high concrete fence (Figure 1) while a short section in the southeast is fenced with standard wire fencing. The estimated circumference of the property is approximately 5.3 km.

Figure 1. Most of the perimeter of Kloofendal Nature Reserve is fenced with a concrete fence.

General management tasks related to fences and gates are the following:

- Ensure that standard locks are used at all gates and a set of keys, as well as a master key, should be available in the office of the reserve manager. The master key should be available in cases of emergencies, for example for access to control runaway fires.
- Maintain and service all gates regularly (paintwork, hinges, chains and locks), but at least annually.
- Regular fence patrols (weekly) should be done to prevent poaching, escape of animals and to fix/replace broken wires, droppers or posts.
- The fence around the old mine should be maintained and patrolled weekly. The area is potentially dangerous and unauthorized access should be prevented.
- A fence patrol sheet should be filed in which the locations of all missing/damaged posts and holes in the fences are specified.

- Close holes/burrows underneath the fence on a continual basis.
- Clear the fence of weeds and grass by spraying herbicides regularly. This cleared strip can act as fire-break and also facilitates patrolling for security reasons. Herbicides such as Roundup Max WG 680 (L6790), Roundup SL 360 (L407), Basta 200 SL (L4872), Tumbleweed (L4781), Mamba 360 SL (L4817), Mamba Max 480 SL, Persuador 360 SL (L6948) could be used for controlling woody species, forbs and grasses along the fence.

3.2 Roads and hiking trails

3.2.1 Hiking trails

One of the most ideal ways to add value to a reserve is hiking trails, which require low input costs and have minimal impact on the environment (Figure 2). The success of a hiking trail is largely dependent on how well such a trail is planned. Any route should attempt to offer as much diversity of interest as possible and should include a diversity of vegetation types. The identification of plants along the route will enhance the hiking experience. Areas overgrown with exotic plants should be avoided.

Figure 2. Well-maintained hiking trail on the plains in Kloofendal Nature Reserve with marker.

Sensitive areas such as marshes, habitats of rare and endangered plant and animal species and sensitive archaeological sites should be identified. Diversity in the ecology and structure of the landscape (geology and topography) and vegetation is necessary for an interesting hiking trail.

An interpretive centre could be located at the starting point or base camp to provide information on a variety of topics related to the particular trail such as geology, vegetation, wildlife and history. Information on the route and the length of the trail, what to see along the trail e.g. plants, birds, archaeological sites and caves and potable water, can be conveyed to the visitor in the form of inexpensive maps and brochures. Signs on what is allowed and what is not allowed in the reserve should be erected at the entrance.

A high standard of maintenance should be ensured through regular patrolling to ensure that the trail stays in good condition, guard against erosion and defacement of rocks, trees and route markers.

3.2.2 Roads

The road network for vehicles on KDNR is very limited at present and a decision should be made as to the feasibility of more roads for patrol, maintenance tasks, firebreaks and emergencies related to fire or injuries to hikers.

The main function of roads on a reserve or wildlife ranch is to provide access for environmental and wildlife management, game viewing, access to infrastructure, act as firebreaks and enhance security, i.e. patrolling of the reserve (Bothma 2010, Cheney 2014). However, roads in natural areas are intrusive and destructive if not properly planned, constructed and maintained. Some sound principles should be adhered to:

- Put in as few as possible roads commensurate with being able to carry out required management tasks.
- Maintain roads regularly to prevent deterioration by weather and through use.
- Roads along the perimeter are advisable for security reasons and to serve as an effective firebreak.
- Remove as little as possible of vegetation during construction. However, cutting back encroaching shrubs for about 1 m from the edge of the road, is part of road maintenance.
- Exposed as little as possible soil to prevent erosion during construction.
- Avoid lowland areas on heavy clay soils, which leave deep ruts and promote erosion.
- Avoid roads along sensitive areas such as drainage lines, streams and rivers unless properly constructed with suitable sandy and gravelly soils.
- Indiscriminate driving off the formal road network and through areas of undisturbed natural vegetation should not be allowed.
- Insensitive driving in difficult terrain, e.g. by not engaging in four-wheel drive, results in damage to the roads by wheel spinning and slipping due to poor traction.
- The road should be well compacted and the profile should be slightly rounded (convex) with good drainage and runoff.
- Humps in the road serve to channel water away from the road, slow down vehicles

and will reduce road kills.

- Poorly sited roads, i.e. in ecologically sensitive habitats, should be closed and rehabilitated.
- Limit use of the roads directly after rain, especially on clayey soils. Mudpools may form and lead to other users bypassing such areas, thereby forming new tracks alongside the original ones, and thus compounding the problem.
- Grading of roads should take place under strict supervision or by a suitably experienced person.
- Remove loose rocks and branches from the roads.
- Regularly fill holes that are caused by burrowing animals.
- Mow the grass in the middle of the road regularly, at least once mid-summer. Where roads are used as fire-breaks, this should be done more often.
- Roads can be a useful tool to facilitate fire management, e.g. as firebreaks. They also provide quick access or escape routes from runaway/unplanned fires and are convenient points from which to initiate back burns to control accidental or unplanned fires.
- Roads create barriers for small animals by cutting off dispersal routes and fragmenting habitats.
- Compacted roads retard the movement of subterranean and burrowing animals.
- Short grass and an abundance of forbs next to roads are good habitat for small herbivores such as the steenbok.
- Accumulation of water next to roads may lead to a dense tall shrub layer.

3.3 Water provision

Continuous heavy grazing by livestock in savannas is known to lead to bush encroachment and the effect of grazing is particularly marked around artificial watering points in southern Africa. If surface water is to be provided in an area, the spacing of these watering points is critical. It is suggested that artificial watering points for wildlife should be well-spaced but in an irregular pattern.

The aim of spacing watering points, as well as closing certain water points during winter, should be to distribute vegetation impacts evenly and to allow plants a period of recovery from severe grazing pressure. Wildlife differ in their relation to and dependence on surface water, e.g. duiker and steenbok. The spatial and temporal distribution of water over the landscape can therefore either directly or indirectly determine the distribution of the different herbivores and their densities. In general, water-dependent wildlife such as the black wildebeest, blesbok and zebra seldom range far from water and are dependent on surface drinking water. The grey duiker, red hartebeest, springbok and steenbok are less water-dependent species, although they will drink water if it is available. The artificial supply of water has a relatively small effect on their population density and distribution.

Figure 3. Dam and bird hide in Kloofendal Nature Reserve.

An oversupply of watering points favours water-dependent ungulates, causes widespread vegetation degradation, increases animal mortality during droughts, decreases ecosystem stability and leads to a loss of biodiversity. The Wilgespruit and the dam provide a permanent source of water (Figure 3). Because KDNR is fairly small the entire reserve can be exploited by water-dependent herbivores from these sources (the distance from the dam on KDNR to the furthest point on the reserve is approximately 1.1 km) (Figure 4).

The current two small troughs around the amphitheatre (Figure 5) could be replaced with one more natural looking watering point to allow small animals and birds easier access to the water (Figure 6). The cement watering point in the central part of KDNR (Figure 7) is right next to the hiking trail and animals would avoid that area during times when hikers use the path. It may be considered to move this watering point further away from the hiking trail. Another watering point is suggested in the spruit in the southwestern parts of KDNR to allow for wider distribution of small mammals and birds that would enhance the hiking experience (Figure 4).

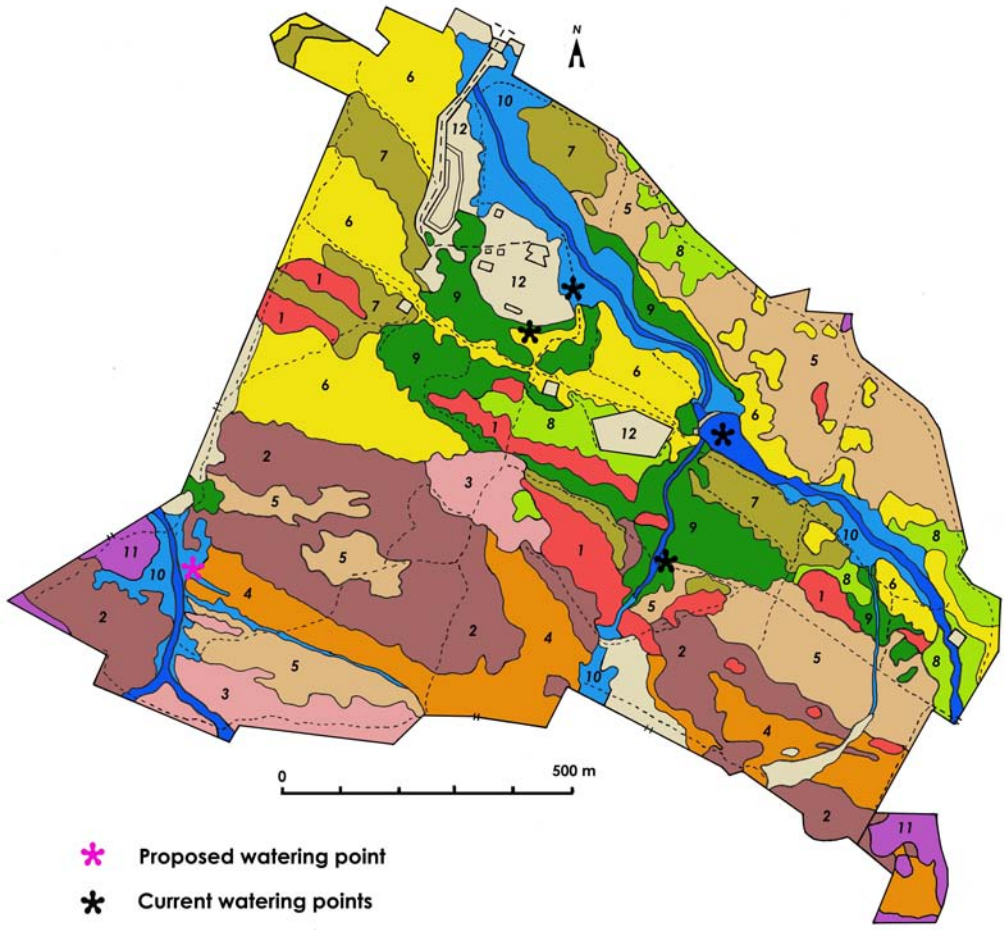

Figure 4. Location of the river and other streams, the dam and the current three watering points on KDNR. Another watering point is suggested in the southwestern part of KDNR.

In a reserve where there is no camp-system to manage the grazing impact of herbivores, the provision of water is one of the few tools besides fire, licks and feed that can be used to manipulate the movement of wildlife in order to avoid site specific under- or overgrazing. This will however not be the case on KDNR where permanent water is available.

Artificial watering points should be designed to resemble natural water points (Figure 7) and must have the option to be closed when needed.

The following general management principles relate to artificial water provision:

- Placement of watering points should avoid areas of heavy traffic and human activities, e.g. location of watering point next to the hiking trail. Construct flat, naturally looking artificial watering points to allow small animals access to water (Figure 7). Fill soil around the watering point when necessary.
- Check dams, tanks, taps, ball valves, waterpumps, belts and watering points regularly.

Figure 5. Watering point in the vicinity of the Amphitheatre.

- Clean watering points regularly.
- Cover ball valves to prevent damage by animals.
- Bury water pipes at least 600 mm beneath the ground surface to prevent damage by animals, e.g. by porcupines. Pipes can be buried in the middle of service roads for easy inspection and repairing of water leaks.
- Check for leaking pipes regularly.
- If salt blocks or anthelmintic blocks are provided near the watering points in winter their location should be regularly changed to prevent build-up of parasites.
- Boreholes and infrastructure such as pumps and solar panels (if present) and water pipes should be protected from animal damage.
- If solar panels are present on the property they should be cleaned regularly and protected from theft.

Water quality

It is good practice to have the quality of the water provided to the animals analysed, especially when using borehole water. The quality of borehole water may have a pronounced influence on the health and production of the animals. Contact Dr Jan Myburgh at the Veterinary Faculty at Onderstepoort, University of Pretoria: Tel 012 529 8452 or 529 8013; Fax 012 529 8315; e-mail: jmyburgh@op.up.ac.za; or (2) Dr James Meyer, Animal Water Specialist Division. Tel. 012 330 0340 or 012 420 4018; james.meyer@up.ac.za for further details.

Figure 6. Watering point right next to the hiking trail.

Figure 7. An example of a watering point for wildlife with a natural appearance and accessible by most animals.

CHAPTER 4

WILDLIFE MANAGEMENT

4.1 Stocking density

The stocking density and types of wildlife to be kept on the Kloofendal Nature Reserve will depend on the objectives of JCPZ for the reserve. The KDNR is currently understocked and home to a few mountain reedbuck and grey duiker as far as small antelope are concerned. Several options can be considered (Table 1):

1. Maintaining the *status quo* with only mountain reedbuck and grey duiker;
2. Maintaining a low stocking density with mountain reedbuck, greyduiker and adding e.g. springbok, red hartebeest and steenbok; or
3. Stocking the reserve to economic capacity with mountain reedbuck, grey duiker and introducing e.g. plains zebra, blesbok, springbok, red hartebeest and steenbok.

Although the first option (*status quo*) will require little input in terms of wildlife management, the other options, in particular option 3, will require the commitment to manage animal numbers in order not to exceed the economic capacity of the reserve.

Table 1. Numbers of wildlife at different scenarios

	Option				
	1: Current numbers	2: Below capacity	3: Full capacity		
			Normal rainfall	Low rainfall	High rainfall
Blesbok	0	12	12	12	20
Grey duiker	10	10	10	10	10
Mountain reedbuck	22	22	20	15	22
Plains zebra	0	0	6	5	6
Red hartebeest	0	0	8	6	9
Springbok	0	15	18	0	18
Steenbok	0	5	5	5	5
ha/LAU (on 90 ha)	**28.1**	**10.1**	**5.6**	**7.9**	**4.9**
ha/LAU (on entire reserve area)	**39.1**	**14.0**	**7.9**	**11.0**	**6.8**

It should be noted that for option 3 the recommended stocking density calculated for normal rainfall conditions exceeds the capacity of the reserve for years below mean annual rainfall and it is therefore imperative that wildlife numbers should be reduced in such dry years to avoid range degradation and/or losses of animals.

Furthermore, as a result of the small size of the reserve, some of the species in option 3 might be reduced to below minimum herd size during dry years. In the above example springbok were totally removed in dry years to allow some of the other species to be maintained close

to minimum herd size. These decisions will depend on the specific numbers of the different species at that particular point in time.

The population growth of all species should be monitored. Live sales, harvesting and/or culling should be implemented to keep the stocking density at or below economic grazing and browsing capacity. At ecological capacity, productivity will be low and overgrazing and overbrowsing will be to the detriment of the veld and animals. Social behaviour, territoriality and home range constraints also play a role in the saturation point of an animal population. Because of the small size of the reserve the numbers recommended for some species, e.g. plains zebra and springbok, are below the minimum herd size generally recommended for wildlife enterprises. These low numbers should slow the rate of increase in these populations.

It is imperative that the current mountain reedbuck males be removed or exchanged for animals from other populations in the region to prevent further inbreeding. The original population of 10 animals was introduced in 2006/7 with no further supplements. The same applies for the grey duiker, where 4 animals were introduced at the same time. Male animals should be removed and new males introduced at most every three years.

4.2 Licks

Fenced wildlife areas restrict movement as well as habitat and food selection by animals. Especially during periods of drought and in the winter months in the Highveld, animals tend to lose condition quickly and this subsequently impacts negatively on the reproduction and general physical condition of the animals. When animals chew on old bones to supplement minerals (known as pica) it may lead to outbreaks of botulism and anthrax.

Continual supplementary feeding throughout the year is not recommended, because it usually indicates that the property is overstocked or that the animals are not well-adapted to the conditions on the property. However, for rare animal species, it is sometimes necessary to supply supplementary feeding such as lucerne, antelope pellets, nutritional supplements, salt blocks and/or licks for short periods in the dry season because of mineral deficiencies in the diet, such as phosphate. Rare animal species are however not recommended for KDNR. Some licks additionally contain anthelmintics to control endoparasites (worms).

Licks and salt blocks should ideally not be placed in veld that is in a poor condition; in sweetveld; against slopes; or on soils conducive to erosion. Ureum should only be used in containers that can drain rainwater.

Information on the composition of winter licks for wildlife, as well as the production of lick blocks and/or wildlife pellets, are for example available from the following companies/websites:

Mineral licks and wildlife pellets are available from companies in South Africa such as:

Wes Wildlife Feed	www.wesenterprises.co.za
Voermol	www.voermol.co.za
Safari Feeds	www.safarifeeds.co.za
Molatek	www.molatek.co.za
Biominerale	www.biominerale.co.za
KK Animal Nutrition	www.kkan.com
ALZU Feeds	www.alzu.co.za

4.3 Parasites and control

Some parasites live on, or in, a host for their entire life or a part of it, without necessarily adversely affecting the host, whereas other parasites cause diseases. Management should decide whether control of endo- and ectoparasites will be part of the wildlife management policy on KDNR.

4.3.1 *Endoparasites*

- Internal parasites include flukes, tapeworms, roundworms and tongueworms. A suitable anthelmintic can be mixed into lick blocks or added to a lick.
- The best time to provide these licks is during the winter because the worms spend the winter in their hosts.
- To get the animals to accept the lick, blocks of salt should be offered first. As soon as the animals have accepted the salt licks, they can be replaced gradually by nutritional licks that contain anthelmintics.
- Lick containers should be anchored firmly to the ground because some wildlife such as zebras may upturn the containers. It is advisable to select new sites for licks regularly to prevent build-up of parasites.

It is important that overpopulation of wildlife be avoided because overpopulation creates favourable conditions for the transfer of parasites. As a result of the veld deterioration due to overpopulation, the animals are then placed under stress. All wild animals that are introduced on wildlife areas should be treated against endoparasites before their release.

4.3.2 *Ectoparasites*

- Ectoparasites include ticks, mites, flies, midges, mosquitoes, horseflies, stable flies, lice and fleas.
- With a few exceptions, all tick species that occur on cattle, also occur on wildlife.
- Animals that are not indigenous to a region can be heavily infested with ticks or suffer from tick paralysis or a tick-borne disease when they are newly introduced to the

region. They may also never adapt to tick-borne diseases and in this way, ticks contribute to protecting the environment against the establishment of exotic animals.

- Ticks can cause anaemia because of their feeding habits, especially in young animals.
- A healthy animal can cope better with the effects of ticks than a sick or injured animal.
- Wild ungulates can generally be dipped or treated with the same compounds as those used for cattle, provided that the directions for use are followed meticulously. Pour-on dips can also be used on wild animals. The Cape eland, Greater kudu, plains zebra, gemsbok, springbok and giraffe are particularly sensitive to build-ups of ticks and a variety of tick-control mechanisms (Figures 8 & 9) are available for these wildlife.
- It is important to monitor and evaluate the effectiveness of tick control systems. More than one system can also be used on a reserve to improve the chances of treating most of the wildlife that may be present. Each system must be regularly inspected and tested and properly maintained to ensure that it stays in good working order.
- Tick-control systems are however unsightly and might spoil the wilderness atmosphere for hikers.
- Overdosage of pour-on dips should be prevented.
- JCPZ could also opt for a hands-off policy regarding parasite control, especially if only mountain reedbuck and grey duiker are stocked at low animal numbers.
- Some of the tick control systems presently available in the wildlife industry include:
  - Duncan Applicator (info@tick.co.za)
  - Tick Off (tickoff@yebo.co.za)
  - Scorpion Dip Applicator (parasites@mweb.co.za)
  - Oom Gielie se dipbak (info@waterberggamedealers.co.za)

Figure 8. Example of a Duncan dip applicator next to a watering point.

Figure 9. Example of a container with feed/lick and tick control dip in a furrow on the edge of container.

4.4 Diseases

A veterinarian should be consulted when it is suspected that an animal died of disease, for example rabies or anthrax. Wildlife diseases and practical veterinary hints for wildlife producers are discussed in Bothma & Van Rooyen (2005), Bothma (2010) and Oberem & Oberem (2011). A short summary of relevant diseases is given below:

- Heartwater is caused by a rickettsial organism and is transferred by the bont tick. Wildlife such as the Cape eland and springbok are sensitive to tickborne diseases, especially in high rainfall areas. Blue wildebeest, impala, African savanna buffalo, greater kudu, giraffe and warthog are susceptible to infection, but do not show clinical signs of the disease.
- Redwater is transferred by ticks and most wildlife have their own *Babesia* species (protozoan). The parasites that cause redwater in cattle do not commonly occur on wildlife, but wildlife can be the host for the blue tick and could transfer the disease to young cattle.
- Cytauxzoonosis is also transferred by ticks and is found in greater kudu, giraffe, roan antelope and grey duiker.
- Anthrax potentially occurs in all mammals, but especially the greater kudu, giraffe and African savanna buffalo are susceptible to anthrax (bacterial disease).
- Snotsiekte is found in the blue and black wildebeest, cattle and sheep. The disease is transferred from the wildebeest to cattle. However, this viral disease does not show clinical signs in the blue and black wildebeest. Contact between cattle and blue and black wildebeest should be minimised.
- Foot-and-mouth disease is a highly infectious viral disease of all cloven-hoofed

animals, with the African savanna buffalo an important carrier of the disease.
- Rabies is found in the greater kudu and is transferred by animals such as the dog, black-backed jackal, bat-eared fox, honey badger and small-spotted genet.

Antrax, foot-and-mouth disease and rinderpest are notifiable diseases of wildlife.

4.5 Handling facilities for wildlife

- Currently there are no loading/offloading ramp, wildlife pens or release bomas on KDNR.
- If needed, offloading ramps should be erected away from fences, water bodies and other potential obstacles for the safe release of animals in KDNR.
- Game catching equipment, pens and bomas are usually provided by the wildlife capture operator.
- Mobile passive-capture systems can be used for game capture, especially in remote areas on difficult terrain.

4.6 Wildlife counts

An integral part of the management of a property is to determine the number of animals of each species on the property on an annual basis. Additionally, it is important to know the sex ratio of these animals for optimal production. It is recommended that wildlife counts be done at least every second year by means of helicopter and crew if numbers cannot be established with confidence by other means.

4.7 Bird collisions – powerlines

Ant-collision devices such as bird flappers should be installed where powerlines cross the reserve (Figure 10).

For information and assistance with power lines and problems with bird collisions, contact:

Constant Hoogstad
Endangered Wildlife Trust - Wildlife & Energy Programme (WEP)
South Africa
Cell:(+27) 082 334 4176

Figure 10. Powerlines cross the KDNR and markers should be installed to prevent bird collisions with the lines.

4.8 Problem species

The rock hyrax population in many of the JCPZ reserves is currently a major problem because of overpopulation. The dassies often leave the reserves and invade neighbouring gardens and homes. In KDNR, the dassie problem has not yet reached the same extreme proportions as in some of the other reserves. Nevertheless, there are areas on the reserve where dassie numbers are excessively high and have to be controlled.

Johannesburg City Parks & Zoo has drafted a short-term strategy to cull a portion of the dassie population in its reserves as it is regarded as the most humane and practical solution to address the current problem. Culling would be done in the dry season by a professional marksman.

CHAPTER 5

RANGELAND RESTORATION

5.1 Current veld condition

The veld condition index of the different plant communities in the KDNR ranged from 24% (very poor) to 48% (moderate), with a mean of 36% (poor)(Figure 11). About 55% of the KDNR was in moderate condition with veld condition indices from 40% to 48%, while 45% of the reserve was in poor condition. From a grazing point of view the veld in the reserve was therefore not in a good condition. However, the poor to moderate veld condition does not necessarily reflect poor veld management on the reserve, but is the consequence of the sour, unpalatable grass species composition that is typical of the nutrient-poor sandy soils (derived from quartzite) in relatively high rainfall areas such as the Highveld grasslands.

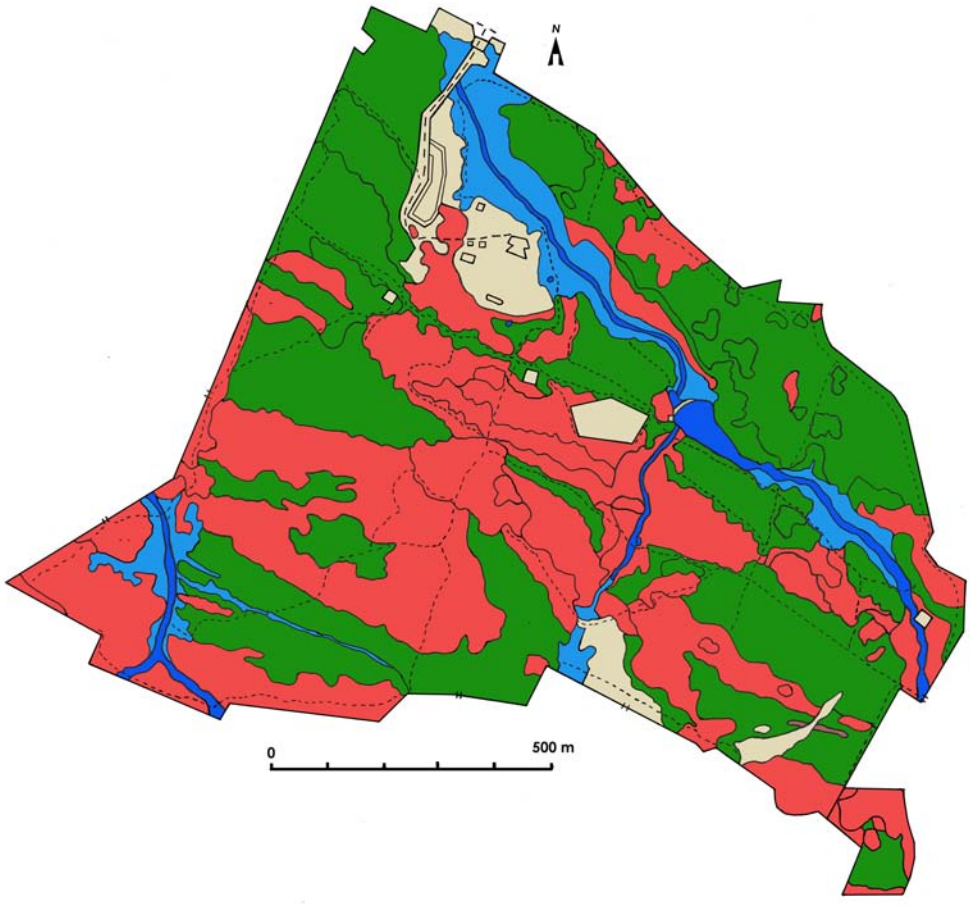

Figure 11. Veld condition in the Kloofendal Nature Reserve based on the 2014 surveys. Red indicates veld in poor condition and green, veld in moderate condition. Disturbed, degraded or fenced areas not available to wildlife are indicated in beige. The riverine community (blue) has low grass cover but abundant material for browse.

The best veld, from a grazing point of view, occurs on the lower lying areas and on less rocky, moderate slopes. The grassland communities (4 & 5) and the open bushveld communities (6 & 7) had a moderate veld condition, whereas the rocky outcrops (communities 1 & 2), grassland community 3 and the thicket communities (8, 9 & 10) had a poor veld condition.

The veld condition, grazing and browsing capacities of the plant communities have to be monitored regularly. Initially, such monitoring should occur annually for at least another four years and thereafter at least every second year.

5.2 Rangeland restoration

Rangeland degradation is a permanent decline in the capability of the land to yield animal products under a given system of management. The root causes of range degradation are overgrazing, loss of vegetation cover, change in plant species composition, bush encroachment, alien plant invasions, soil degradation and soil erosion by water and wind.

Rangeland restoration (or rehabilitation) is the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed. Management of ecological integrity (biodiversity, ecological processes) involves re-enforcement practises (active restoration technologies) by mechanical and biological techniques, to increase the production potential and grazing capacity of the degraded rangeland. Restoration programmes are costly and therefore require absolute long-term dedication to the project. However, economic realities often dictate that the restoration methods used should be of a low cost nature.

Restoration projects often fail because all the aspects of a restoration plan are not implemented. Minor degradation of rangelands that still retain essential resources, such as vegetation cover, organic material, water, soil and nutrients, can be reversed by proper grazing management and controlling excessively dense woody plants.

Severe range degradation can be caused by persistent heavy grazing, invasion by alien plant species, encroachment by indigenous species, as well as lack of veld fires to rejuvenate the grass layer. Persistent heavy grazing has not occurred in KDNR over the past few decades. However, there are patches where aliens have invaded, e.g. community 10 (see Chapter 7) and signs of shrub encroachment are evident (communities 2, 6 & 7)(see Chapter 6).

If needed, a rehabilitation expert such as Mr K. Coetzee of Conservation Management Services can also be contacted at consken@mweb.co.za or his reference book on rangelands and rehabilitation could be consulted (Coetzee 2005).

5.3 Erosion control

Some erosion is evident on some of the hiking trails against steep slopes and these areas should be maintained (Figure 12). Where necessary, sheet and gully erosion should be controlled by the establishment of a vegetation cover through water retention measures by, e.g. gabions (see Figure 13). These structures could also be built along the ephemeral streams to stabilize the waterflow during rain storms, or serve as watering points for fauna.

Figure 12. Some degradation of hiking paths against steep slopes.

Figure 13. Example of gabion structure to control erosion and stabilize drainage lines or provide water for animals.

The following general guidelines should be considered when planning erosion control measures:

- First priority should be given to erosion that is in the initial stages rather than the advanced stages and control should be concentrated at the heads of gullies.
- The type of gabion (or barrier) that is used should be determined by the availability of material close to the areas to be treated. Silt traps should be placed in the upper reaches (or head) of the erosion system. Materials such as rocks, geotextile netting and brush can be used.

CHAPTER 6

BUSH ENCROACHMENT

6.1 Introduction

Bush encroachment is currently a problem worldwide and is also evident in KDNR. A comparison of the historical aerial photograph of 1941 with a recent satellite image clearly indicates the areas where woody densification has occurred (see main report). Densification is most apparent in the riparian zone (community 10) and all alien invasion plants should nevertheless be eradicated in this zone. The current dense bushveld communities (communities 8 & 9) to the south of the Wilgespruit, were not visible in the historical aerial photograph. Signs of densification are also visible in the open bushveld communities (communities 6 & 7), with community 7 being notably denser than community 6 on the recent satellite image.

Generally, bush encroached areas are characterised by the dominance of one or two species, however, the dense bushveld communities 8 and 9 have a fairly diverse assemblage of woody species. These habitats afford protection for animals against inclement weather. Species with high densities in these communities were:

**Acacia caffra*	Community 9
Gymnosporia buxifolia	Community 9
Celtis africana	Community 9
Buddleja salviifolia	Community 9
Diospyros lycioides	Communities 8 & 9
Searsia pyroides	Communities 8 & 9

*New name *Senegalia caffra*

The first priority for controlling bush encroachment on KDNR should be the open bushveld communities 6 and 7. Species with high shrub densities in these communities were:

Leucosidea sericea	Community 6
Searsia lancea	Community 6
Afrocanthium spp.	Community 6 & 7
Searsia pyroides	Community 6 & 7
Diospyros lycioides	Community 7

Although dwarf shrub encroachment is not clearly visible on the satellite image, this has occurred in some of the communities on KDNR. The main problem **dwarf shrub** species and communities were:

Lopholaena coriifolia	Community 2
Seriphium plumosum	Communities 6 & 7

When controlling encroachment approximate threshold values to strive for dwarf shrubs are not more than 1500 plants/ha and not more than 600 individuals/ha for shrubs.

6.2 Methods of controlling bush encroachment

Background to the problem was provided in Chapter 7 of the main report.

An on-site evaluation is advisable to determine the level of thinning of plants required. A combination of mechanical and chemical control is generally recommended, with follow-up treatments of coppice growth after two to three years. There are three basic methods to control encroachment:

6.2.1 Physical (mechanical) control mechanisms

Chopping, slashing and felling: An axe, hand or tractor-driven chain or circular saw or brush cutter can be used. Stumps should be **treated immediately** with a chemical weed-killer to prevent coppicing.

Ring-barking (girdling): The bark of trees is removed around the trunk with an axe or power-driven saw. The exposed bark area should preferably also be treated with a herbicide. Trees that have been ring-barked in such a way, usually die within one to three years.

6.2.2 Chemical control mechanisms

A wide range of chemical herbicides is available under a range of trade names (see Grobler *et al.* 2000, Henderson 2001, XACT 2005, Bromilow 2010, Van Zyl 2012). It is important to follow the instructions on the label of the product regarding application, safe and proper use and storage (Jordaan 2014).

Foliar application:
The chemicals are applied with a hand spray or a power-driven spray mounted on a trailer, tractor, truck or aircraft. The best time to spray is when the leaves of the plants are growing actively.

Stem-notching and application:
This method is the most effective for trees with a trunk diameter of less than 150 mm. Downward notches are made around the lower 300 to 500 mm of the trunk and the chemical is either sprayed or painted on that area.

Stump treatment:
Trees and shrubs are cut off at approximately 200 mm or less above ground level. The stumps should be cut horizontally and not at an angle because the resultant sharp spikes may harm animals or damage equipment. The cut stumps should be treated immediately with a

herbicide. The advantages are that the extent of the thinning process can be seen immediately, and that the cut branches can be used as firewood or to cover bare areas. The method has a low chemical use, the application is selective, and the result is aesthetically acceptable. Mechanical implements are available to deal with dense and thorny bushes such as chain saws, brush cutters or motorized machines, e.g. BOSCUT & BARKO machines.

Soil treatment:
The chemical is applied in the form of a water-soluble liquid or powder on the soil at the base of the trunk or is buried in the case of granules (pellets). The chemical is then dispersed during the rainy season and taken up by the roots of the target plant. These chemicals are most effective in sandy soils. The chemicals remain active in the soil for up to four years and, depending on the rainfall, it may take two to three years for the plants to die.

6.3 Post-control treatment (after-care)

- Wherever bush control measures have been applied, it is imperative to monitor the reaction of the vegetation to these interventions.
- Treated veld should be rested for at least one season to increase grass seed and forage production, whereafter prescribed fire and herbivores may be introduced. These areas should preferably be temporarily fenced off to exclude herbivores (would not be needed if reserve is very understocked as in option 1, chapter 4).
- Veld burning contributes to the partial control of woody encroachers and where a bush control programme is implemented. After-care should include prescribed burning depending on the grass biomass (fuel load) available.
- After bush control has been implemented, renewed bush encroachment must be prevented by maintaining a productive grass layer through sound veld management and/or the treatment of coppice growth with herbicides.
- It is essential that the stocking density should initially be conservative, bare areas should be reclaimed and grass growth promoted.

6.4 Control of problem plant species on Kloofendal Nature Reserve

Reports on the control of indigenous encroacher species often contain contradictory statements. Treatments applied in the control of the species on KDNR could be used as topics for student projects.

6.4.1 ***Seriphium plumosum*** *(*bankrupt bush)

Bankrupt bush (*Seriphium plumosum*) is inclined to increase as a result of overgrazing or where veld was degraded and forms dense stands locally, especially in abandoned fields and along seepage lines on poor sandy soils. However, Wepener (2007) found that encroachment by bankrupt bush could also occur in veld in good condition if the habitat

conditions are suitable for encroachment, e.g. on rocky sandy soils. In the early stages of encroachment the bushes can be removed manually and burned. This should be done regularly in early spring before the plants produce their seeds (Wepener 2007). However, the seed bank in the soil will still be present and follow-up control should be applied. It was found that although fire stimulates seed germination of bankrupt bush (Jordaan 2011, Snyman 2011, control of seedlings could be achieved with controlled burning treatments (Snyman 2011, Du Toit *et a*l. 2013), but Wepener (2007) found that burning and manual treatments of mature plants may lead to higher densities *if not properly managed*. It was found that although 70% of all seedlings were killed by fire, the fire did not kill mature shrubs. However, fire significantly stimulated seedling emergence afterwards. A good grass cover suppresses the growth of these encroacher plants. When dense stands occur, chemical control is another option.

According to Wepener (2007), Snyman (2011, 2012) and Du Toit (2012) the most successful ways of combating *Seriphium plumosum* invasions are by using herbicides and/or by removing the bushes manually, but follow-up treatments are essential. When removing the plants manually, care has to be taken to not to leave belowground parts of the plant. However, herbicide treatment should be done with care and preferably with selective and residual herbicide such as metsulfuron-methyl (e.g Trade name: Brush-Off)(Du Toit 2012). Herbicides such as Tebuthiuron (e.g Trade name: Limpopo) are not recommended as control agents for bankrupt bush.

A large number of herbicides are registered for bankrupt bush and include trade names such as Molopo 200 GG, Limpopo SC, Limpopo 800 WDG, Ranger 240 EC and Garlon 480 EC. Application of herbicides can be aerial, foliar or soil application.

*6.4.2 **Lopholaena coriifolia*** (fluff bush)

The fluff bush is indigenous to Mpumalanga and Limpopo provinces and is particularly invasive in the Waterberg region of Limpopo, inassociation with bankrupt bush. Fluff bush is unpalatable to animals and once established, it spreads rapidly together with bankrupt bush and can become a serious invader that causes degradation and reduced biodiversity (ARC SAPIA (2013) and Information Sheets of the Waterberg Nature Conservancy.

Elimination or control is problematic because the destruction of the Above-surface parts by fire or herbicides can stimulate rhizomes (roots), to shoot and produce more flowers. However, repeated application can be successful. Physical removal, including removal of flowewr heads, cam control and eventually eliminate the plant.

Herbicides should be applied as early as possible in the growing season, preferably before flowering. All herbicides should be used when freshly mixed and the instructions on the herbicide label should be followed carefully.

Foliar application (e.g. with knapsack sprayer)

Active ingredient: picloram 240 g/ℓ SL

Trade name: **Access** 240 SL (L4920); Browser (L7357)

6.4.3 *Acacia caffra*

The following chemical control measures could be taken:

Cut stump and foliar application:

Active ingredient: picloram 240 g/ℓ SL (solution)

Trade names: **Access** 240 SL (L4920), **Browser** (L7357)

Soil treatment:

Active ingredient: bromacil 100 g/kg GR (granules)

Trade name: **Bromacil** 100 GR (L2559)

Active ingredient: bromacil 200 g/kg GG (macrogranules)

Trade name: **Bushwhacker** GG (L7103)

Active ingredient: bromacil 500 g/ℓ SC (suspension concentrate)

Trade name: **Bushwhacker** SC (L6706)

Active ingredient: bromacil 800 g/kg WP (wettable powder)

Trade name: **Brush-Free** WP (L6220)

Active ingredient: bromacil/tebuthiuron 250/250 g/ℓ SC (suspension concentrate)

Trade names: **Bundu** SC (L7517), **Savanna** 500 SC (L6090)

Active ingredient: tebuthiuron 200 g/kg GG (macrogranules)

Trade name: **Molopo** 200 GG (L6111)

Active ingredient: tebuthiuron 500 g/l SC (suspension concentrate)

Trade names: **Molopo** 500 SC (L5854), **Limpopo** (L7199)

Active ingredient: tebuthiuron 800 g/kg WG (water dispersible granules)

Trade name: **Molopo** 800 WG (L7043)

6.4.4 *Leucosidea sericea*

Cut stump treatment

Active ingredient: imazapyr 100 g/ℓ SL

Trade names: Chopper (L3444); Hatchet (L7409)

Soil treatment

Active ingredient: tebuthiuron 200 g/kg GG
Trade name: Molopo 200 GG (L6111)

No herbicides are registered for *Diospyros lycioides* or *Searsia pyroides*.

6.5 Benefits and pitfalls of herbicide usage (Jordaan 2014)

The act controlling agrochemicals is known as the Agricultural Remedies and Stock Remedies Act (No. 36 of 1947). It is stipulated that the end user must comply with the label of a particular product. It is also stipulated that the user cannot legally apply these products, i.e. to make money of applying pesticides for someone else, if the user is not registered under the Act as a pest control operator (PCO) with DAFF. Landowners have a duty to insist on proof of registration when approached by potential herbicide application contractors.

- Using (applying) a pesticide in a way that conflicts with the label, is against the law. The contractor will be breaking the law if a herbicide is used to control a specific plant species if that pesticide is not registered for that species.
- Herbicides are much more effective when weedy species are growing actively and younger plants are generally easier to control. To clear a wildlife fence of weeds, apply the herbicides early in the growing season and not in autumn or when plants are wilted.
- Foliar-absorbed herbicides should not be applied if the leaves of plants are covered with dust, especially glyphosate-based chemicals.
- Silt-laden water and water with calcium carbonate ions may deactivate glyphosate-based herbicides.
- Root-absorbed herbicides are not species specific and may target any tree or shrub in the vicinity of the application.

CHAPTER 7

ALIEN INVASIVE PLANT SPECIES

7.1 Introduction

An "invasive species" is any species whose establishment and spread outside of its natural distribution range (i) threatens ecosystems, habitats or other species or has a demonstrable potential to threaten ecosystems, habitats or other species; and (ii) may result in economic or environmental harm or harm to human health. Invasive alien plant species are globally considered as one of the greatest threats to biodiversity and ecosystem integrity.

According to the Conservation of Agricultural Resources Act (No. 43 of 1983 - Regulation 15, 30 March 2001), and the National Environmental Management Act: Biodiversity Act (No. 10 of 2004)(NEM:BA 2014), invasive alien plant species should be controlled and eradicated with an emphasis on urgent action in biodiversity priority areas.

What is the extent of the problem?
Overall, the alien plant infestation in the KDNR is currently light to moderate and it would therefore be prudent to remove these plants before they become a serious problem.

Which species are implicated?
A total of 86 alien plant species have been recorded in KDNR of which 47 are Category 1b species (Table 2).

The legal requirement for Category 1b species is to "contain" the invasive species. However, where an Invasive Species Management Programme has been developed for a Category 1b species, then landowners are obliged to "control" the species in accordance with the requirements of that programme. All Category 2 species recorded in KDNR must be regarded as Category 1b species because they are not cultivated for economic purposes and no permit has been issued for them. Category 3 species inhabiting riparian zones must also be regarded as Category 1b species.

The infestation of five species (*Acacia mearnsii, Eucalyptus camadulensis, Lantana camara, Celtis australis* and *Cotoneaster franchetii*) was regarded as problematic in certain communities, whereas infestation was considered low (although often widespread) for most species. The level of infestation and localities of alien species identified by other persons were not available.

Which communities are most affected?
Community 10 contained the most alien invasive species, followed by communities 11, 12, 9, 2 & 6. The communities with the least alien invasive species were 1, 3, 4, 5 and 7 (see Figures

9 and 30 of Part 1). Control of alien species along the Wilgespruit should receive immediate attention because of their impact on flow of water, soil stability and biodiversity in general.

Table 2. Category 1b declared alien invasive species in KDNR and their level of infestation

Species	Severity of infestation	Community
Acacia dealbata	Not recorded in current study	
Acacia elata	Not recorded in current study	
Acacia mearnsii	Widespread, problem only in community 12	5, 6, 8, 9, 10, 11, 12
Acacia melanoxylon	Widespread, low	1, 4, 6, 7, 8, 10, 12
Agave americana	Local, low	3
Ageratina adenophora	Not recorded in current study	
Araujia sericifera	Local, low	9, 10
Argemone ochroleuca	Not recorded in current study	
Bryophyllum delagoense	Local, low	10
Campuloclinium macrocephalum	Widespread, low	3, 5, 6, 9, 12
Celtis australis	Local, moderate	11, 12
Cereus jamacaru	Noted in current study, low	
Cestrum laevigatum	Local, low	3, 11
Cirsium vulgare	Not recorded in current study	
Cortaderia selloana	Noted in current study, low	
Cotoneaster franchetii	Widespread, moderate	6, 7, 8, 9, 10
Crotalaria agatiflora	Local, low	10, 12
Cuscuta campestris	Local, low	2, 12
Datura stramonium	Not recorded in current study	
Eucalyptus camaldulensis	Problem in community 11	9, 11, 12
Ipomoea indica	Not recorded in current study	
Ipomoea purpurea	Local, low	2, 10, 11, 12
Jacaranda mimosifolia	Local, low	2, 3
Lantana camara	Problem in communities 2, 11	2, 6, 8, 9, 11
Ligustrum japonicum	Local, low	7, 10
Ligustrum ovalifolium	Not recorded in current study	
Malva verticillata	Not recorded in current study	
Melia azedarach	Local, low	9, 10, 12
Mirabilis jalapa	Local, low	11
Morus alba	Only noted in current study	
Opuntia aurantiaca	Not recorded in current study	
Opuntia ficus-indica	Local, low	2
Opuntia spinulifera	Only noted in current study	
Pennisetum clandestinum	Local, low	10, 11, 12
Persicaria capitata	Local, low	10
Phytolacca icosandra	Local, low	7, 10, 11
Pinus sp.	Local, low	2
Pyracantha angustifolia	Local, low	6, 7, 10

Robinia pseudoacacia	Local, low	10
Solanum elaeagnifolium	Not recorded in current study	
Solanum mauritianum	Widespread, problem in community 11	2, 4, 6, 7, 8, 9, 10, 11
Solanum pseudocapsicum	Local, moderate	8, 9, 10
Solanum sisymbrifolium	Not recorded in current study	
Tecoma stans	Not recorded in current study	
Tradescantia fluminensis	Not recorded in current study	
Verbena bonariensis	Local, low	10, 11, 12
Verbena brasiliensis	Not recorded in current study	

What to strive for?

Although total eradication of many of the alien invasive species is not realistic, the eradication of some of the species can be achieved, e.g. *Opuntia ficus-indica, Cereus jamacaru, Morus alba, Agave americana, Melia azedarach, Cortaderia selloana* and *Solanum mauritianum*.

Prioritization of species

We would suggest the species be prioritized in the following order:

A. Species for full eradication

- *Opuntia ficus-indica*
- *Cereus jamacaru*
- *Solanum mauritianum*
- *Cortaderia selloana*
- *Jacaranda mimosifolia*
- *Melia azedarach*
- *Morus alba*
- *Pinus* sp.
- *Agave americana*
- *Bryophyllum delagoense*
- *Tecoma stans*

B. Woody species for long-term commitment

- *Acacia mearnsii*
- *Lantana camara*
- *Acacia melanoxylon*
- *Cestrum laevigatus*
- *Cotoneaster franchetii*

C. Herbaceous species for long-term commitment

- *Campuloclinium macrocephalum*

- *Phytolacca icosandra*

Working for Water could be contacted to clear the stands of *Eucalyptus camaldulensis, Acacia mearnsii* and *Acacia melanoxylon*.

7.2 Control of alien invasive plant species

7.2.1 Some general principles regarding the control of alien invasive plant species

- Maintain a healthy grass cover by sound veld management and judicious burning of the grass sward.
- Create a buffer zone of alien-free vegetation around protected areas.
- Limit their introductions by humans, such as into gardens, with animal fodder and with thatch grass.
- Light infestations are easier to deal with than heavy infestations.
- Infestation generally proceeds downhill and downstream, particularly when considering riverine vegetation. Clearing operations should start at the highest point and work downwards since it is ineffective to clear an area when an infestation reservoir exists uphill or upstream.
- No control operation succeeds the first time. One or more follow-ups are essential. Cleared areas should be inspected at regular intervals to ensure that elimination is complete. If control has not been successful then follow-up control has to be applied.

7.2.2 Control mechanisms (see also Chapter 7 of Part 1)

Controlling alien invasive plants is a costly exercise. It is important to evaluate the expenditure on the control in terms of the benefits that are gained from improved ecosystem goods and services (Jordaan 2014).

Environmental damage that must be avoided during control operations of alien plants includes:

- the removal of non-target plants;
- herbicidal damage to non-target plants;
- the chemical pollution of soil and/or water;
- the irresponsible use of fire;
- creation of a fire hazard by allowing flammable material to accumulate in fire-sensitive areas;
- unnecessary or irresponsible soil disturbance, especially on riverbanks or slopes; and
- failure to rehabilitate denuded areas to prevent soil erosion and invasion by other undesirable species.

7.2.2.1 Mechanical and/or chemical control:

- Alien invaders can be controlled by mechanical and/or chemical means.
- Mechanical means include ringbarking (girdling), uprooting, chopping, slashing and felling. An axe, chain saw or brush cutter can be used.
- Stumps or ringbarked stems should be treated immediately with a chemical weedkiller (see references below).
- Follow-up treatment is usually needed (see also Chapter 7 of Part 1 Main report).

7.2.2.2 Biological control:

- Biological control is the most cost-effective and sustainable control method against invasive alien plant species.
- It may only be initiated by and carried out under the supervision of an organisation established by legislation, which practises and researches biological control of weeds and invader plants. The Plant Protection Research Institute could be requested to assist with biological control.
- Effective bio-control agents cause gradual thinning of dense stands of invading alien plants, thus allowing the natural vegetation to return as part of the natural process.

7.3 Control of alien invasive plant species in Kloofendal Nature Reserve

Mechanical control could be used for:

- *Melia azedarach*
- *Agave americana*
- *Morus alba*
- *Phytolacca icosandra*

With the assistance of Agricultural Research Council - Plant Protection Research Institute, biological control could be investigated for:

- *Cereus jamacaru*
- *Acacia melanoxylon*
- *Solanum sisymbrifolius*

7.3.1 Campuloclinium macrocephalum (pom-pom weed)

The use of biological control of pom-pom is still being investigated. Mechanical control by cutting of flower heads and/or pulling out plants has met with little to moderate success, unless all succulent roots are removed. The plants have the ability to grow again from succulent roots that were left behind.

Chemical control seems to be the best solution. The one herbicide that works well is "Brush-off" (DuPont), with metsulfuron methyl at 600 g/kg active ingredient. It consists of fine water

soluble granules which are mixed with water, combined with a surfactant and dye. The herbicide is systemic and works well at low concentrations (15 – 20 g/100 liter water). Unfortunately it has a residual effect in the soil and the herbicide must be carefully used particularly in wetlands. The herbicide does not affect grasses but because indigenous broad-leaved herbs (forbs) may be affected, selective spot-spraying should be applied. The best time to spray is early in the season at the start of flowering time before seeds have developed.

Chemical control can be used for:

- *Opuntia* species
- *Cereus jamacaru*
- *Cirsium vulgare*
- *Acacia mearnsii*
- *Solanum mauritianum*
- *Melia azedarach*
- *Cortaderia selloana*

A large number of herbicides are registered for the control of alien invasive species (see booklets by XACT 2005; Van Zyl 2012).

7.3.2 ***Opuntia* species (prickly pear)**

All plants should be destroyed. The weedkiller must be injected into the stems of the prickly pear. The agent is toxic to animals (especially rhinoceroses) and may kill them if they utilise the plant after it has been sprayed.

Stem injection:

Active ingredient:	MSMA 720 g/ℓ SL (solution)
Trade name:	**MSMA** 720 SL (L3754, L7279)
Active ingredient:	Glyphosate (ammonium) 680 g a.e./kg WG
Trade name:	**Roundup Max** (L6790)
Active ingredient:	Glyphosate (isopropylamine) 360 g a.e./ℓ SL (solution)
Trade names:	**Buggie** 360 (L6086), **Glyphosate** 360 (L4732, L4756), **Profit** (L4774), **Roundup** (L407), **Strip** (L6752), **Sunup** (L4687)

7.3.3 ***Cereus jamacaru* (queen-of-the-night)**

Stem injection:

Active ingredient:	MSMA 720 g/ℓ SL

Trade name: **MSMA** 720 SL (L7279)

7.3.4 Cirsium vulgare (Scotch thistle, spear thistle)

Foliar application:

Active ingredient: clopyralid/triclopyr 90/270 g/ℓ SL
Trade name: **Confront** 360 SL (L7314)

Active ingredient: fluroxypyr/picloram 80/80 g/ℓ ME
Trade name: **Plenium** 160 ME (L7702)

Active ingredient: picloram 240 g/ℓ SL
Trade name: **Acces**s 240 SL (L4920)

7.3.5 Solanum mauritianum

A large number of herbicides are registered for this weed and include herbicides for basal stem application, cut stump application, foliar application and soil treatment (Van Zyl 2012).

7.3.6 Melia azedarach (seringa)

Melia azedarach may be controlled with a basal stem treatment, cut stump treatment, frill treatment or soil treatment.

Soil treatment:

Active ingredient: triclopyr 240 g/ℓ EC
Trade name: **Ranger** 240 EC (L6179)

Active ingredient: triclopyr 480 g/ℓ EC
Trade names: **Garlon** 480 g/ℓ (L4916), **Viroaxe** (L6663)

Cut stump treatment:

Active ingredient: clopyralid/triclopyr 90/270 g/ℓ SL
Trade name: **Confront** 360 SL (L7314)

Active ingredient: picloram 240 g/ℓ SL
Trade name: **Access** 240 SL (L4920)

Other herbicides that can be used as cut stump treatment, are **Plenum** 160 ME (L7702), **Arborex** (L8777) and **Timbrel** 360 SL (L4917). For frill treatment, **Confront** 360 SL (L7314) and **Plenum** 160 ME (L7702) could be used. For soil treatment, **Bushwacker** GG (L7103) and **Bushwacker** SC (L6706) could be applied.

7.3.7 *Acacia mearnsii* (black wattle)

A large number of herbicides is registered for the treatment of *Acacia mearnsii* (see Van Zyl 2012).

7.3.8 *Cortaderia* spp. (*C. selloana* and *C. jubata*) (pampas grass)

These alien invasive grass species could be treated with a foliar application using **Kilo** WSG (L7431) with active ingredient of glyphosate 500 g a.e./kg WG (sodium salt).

The toxicology of the active ingredient glyphosate is as follows (DT50 is time for 50%; half-life):

Mammals: practically non-toxic, slight eye irritant
Birds: practically non-toxic to slightly toxic
Fish: practically non-toxic to slightly toxic
Worms: practically non-toxic to slightly toxic
Persistence in environment: DT50 in soil is 1 – 130 days

7.3.9 *Lantana camara* (lantana)

Granule application or spraying of actively growing plants is recommended. Never slash lantana without applying chemicals afterwards. A large number of chemicals are registered for lantana:

Active ingredient: glyphosate
Trade names:
SL: **Clear Out** 180; **Cobra** 180 SL; **Sting**; **Swift** 180; **Tumbleweed; Roundup** CT; **Roundup Pro; Glyphosate** 360; **Mamba** 360 SL
AL: **Stirrup**

Active ingredient: glyphosate trimesium
Trade names: SL: **Touchdown; Touchdown Plus; Wipe-out**

Active ingredient: imazapyr
Trade names: SL: **Chopper**

Active ingredient: picloram
Trade names: SL: **Access**

Active ingredient: picloram/trichpyr
Trade names: OL: **Tordon Super**

Active ingredient: tebuthioron

Trade names:

GG: **Molopo** 20 GG

SC: **Tebusan** SC; **Railroad** SC; **Molopo** SC; **Grazer** SC

WG: **Tebusan** 90 WG; **Molopo** 90 WG

The toxicology of the active ingredient **imazapyr** is as follows (DT50 is time for 50%; half-life):

Mammals: practically non-toxic, slight eye irritant, mild skin irritant

Birds: practically non-toxic

Fish: practically non-toxic

Bees: >100 ug/bee

Persistence in environment: Soil residual activity is 3 months to 6 months in tropical areas to up to 2 years in temperate regions.

CHAPTER 8

FIRE

8.1 Introduction

The application of fire as a management option should be carefully considered in KDNR. Patch mosaic burning is currently proposed for savannas where fire is introduced to create a mosaic of patches representative of a range of fire histories to generate heterogeneity across space and time (Parr & Anderson 2006). A veld condition and fuel load assessment should be done before the decision is made to burn an area.

In practise the implementation of a fire programme is easier said than done, even when an agreement has been attained on its nature (e.g. lightning-ignited, patch mosaic burning; prescribed regular fire). Unplanned fires often burn large areas, which disrupts the fire targets that have been agreed upon by management.

8.2 Firebreaks

According to the National Veld and Forest Fire Act (No. 101 of 1998) in South Africa, a duty is placed on owners of natural veld to prepare and maintain firebreaks on their side of the perimeter fence. Detailed requirements on fire protection associations, firebreaks and fire fighting equipment, are described in the Act.

The risk of fires spreading out of control and causing damage is high in parts of the reserve where a high fuel load was measured, e.g. patches in community 12. Therefore, it is compulsory to create firebreaks around the boundary of the reserve and the same could be done around other infrastructure bordering on natural veld. Especially buildings with thatch roofs should be protected against fire by using for example water sprinklers on the roofs and around buildings. Annual firebreaks are generally burnt in winter. Once effective firebreaks have been established it is possible to use fire for ecological reasons, but this should only be undertaken by experienced teams (see BOX 1 for fire fighting equipment; Cheney 2013).

8.3 Grass biomass

Based on the biomass data obtained during the 2014 surveys (Table 20), some projections can be made as to how the vegetation in the various communities will respond to fire. Community 12 currently has a mean fuel load in excess of 5000 kg/ha, mainly because of the stands of *Hyparrhenia tamba* in certain areas in community 12. Such a high fuel load will support a very hot fire. Communities 2 to 8 have mean biomass values of between 2000 kg/ha and 4000 kg/ha. These communities therefore have fuel loads that can sustain grass fires (Table 24). Under hot and dry conditions community 2 will probably sustain a hot fire. The herbaceous biomass in communities 6 and 7 is not sufficient for controlling bush

encroachment since values in excess of 4000 kg/ha is recommended for bush control. Nevertheless, controlled burning can form part of an integrated strategy to control bush encroachment. It is an ecologically acceptable method because it is regarded as a natural factor of the environment.

Table 3. Grass biomass of the different plant communities of Kloofendal Nature Reserve

Plant community number	Area (ha)	Biomass (kg/ha)
2	25	2642
3	7	3878
4	12	3319
5	25	3119
6	23	3004
7	10	2887
8	6	3341
12	2	5681
Total	110	3484

BOX 1. Fire fighting equipment (Cheney 2013)

Personal safety equipment: Fire-proof cotton overalls with long sleeves; helmet; fire-proof gloves; heavy, thick-soled boots; masks covering nose and mouth. No plastic or nylon clothing with is highly flammable and melts into the skin when ignited.
Metal rakes, spades & hoes.
Beaters: Wooden-handle beaters made of strips of old conveyer belting.
Knapsack sprays: Knapsack tanks filled with water to douse smaller flames, burning logs or smouldering dung.
Drip torches: Drip torches are mixed with petrol and diesel and are used to start the fire.
'Bakkie-sakkie': A water tank on the back of a vehicle with a petrol-driven high-pressure pump to spray water.
First-aid equipment: A well-equipped first-aid kit is essential, especially to treat minor burns.
Two-way radios: Good communication is essential during fire-fighting operations.

It should however be noted that research on the impact of fire on mortality of woody species indicated that up to 90% of the woody plants usually survive a fire treatment, and that it obtains only partial control of encroacher species (Skarpe 1980, Sweet & Mphinyane 1986).

8.4 Preparations before burning

Before implementing prescribed burns it is essential that the infrastructure to control fires is in place: fire fighting equipment, water, fire-breaks and manpower. An accurate local weather forecast is highly recommended before a prescribed burn. Only certain wind directions, wind speeds, relative air humidity and temperatures are acceptable, depending on the purpose of the burn. Wind speeds up to about 14 km/h (3.8 m/s) increase the rate of spread of head

fires, but have no effect on back-fires.

The decision whether or not to burn should always be based on the condition of the veld in question. Burning is usually recommended after the first significant rains (>25 mm) in spring in areas with an unpredictable climate. When hot fires are implemented in spring before the rains, there is always the risk of a long period without rain after the burn, and therefore loss of grazing.

If a 'cool' fire is needed to minimise damage to trees and grasses, the following criteria should be met before a burn is applied:

- the fuel load should not be higher than 3000 kg/ha;
- the moisture content of fuel >40%;
- air temperature <25°C;
- relative air humidity >40%;
- wind speed <5 km/h;
- burn in late spring and early summer after rain; and
- burn in the early morning or late afternoon.

When a 'hot' fire is needed, for example for bush control, the following recommendations are usually made:

- grass fuel loads (>4000 kg/ha);
- moisture content of fuel <20%;
- air temperature >27°C;
- relative air humidity <25%;
- wind speed 5 to 10 km/h;
- season of burn is spring and early summer; and
- time of day is between 12:00 and 15:00.

8.5 Managing fire and preparing fire-breaks

According to the patch-burn approach burns are initiated at random points and the fire is allowed to burn in a random manner until it burns itself out.

Fire-breaks can be prepared in a number of ways:

- Use a road as one of the boundaries and clear another strip with handtools, e.g. mowing, tractor and grader or plouging. The section in between is then burnt.
- A broad strip can be mowed so that a strip of very short grass remains. This will not necessarily stop the fire, but will allow a point of control.
- Two strips can also be prepared in autumn by using herbicides to kill the vegetation. Once the vegetation in each strip is dead and dry, these strips can be burnt in winter. In late winter the section between the strips is then burnt.
- Fighting unplanned or run-away fires is described in BOX 2 (Cheney 2013).

BOX 2: Fighting unplanned or run-away fires (Cheney 2013)

- Warn people along the path of the approaching fire.
- Remove all personnel, visitors, pets and livestock from the path of the oncoming fire immediately.
- Unplanned or accidental fires must be fought with fire. Backburns must be initiated from fire-breaks or roads. Always burn into the wind (backfire)

8.6 Guidelines for Kloofendal Nature Reserve

The following guidelines for a fire programme are proposed (see Figure 14):

- Divide KDNR into different burning 'sections' with firebreaks surrounding each section (see Figure 14).
- The fire protection unit of Kloofendal Nature Reserve (or fire-brigade of the area), should be on standby when an area is to be burnt.
- Fire-breaks should be made around the built-up areas and other infrastructure before burning an area. Especially buildings with thatch roofs should be protected against fire.
- Owners of adjoining land and the Fire Protection Association for the area should be informed when prescribed burning is planned.
- As a long-term aim, lightning fires should be allowed to burn undisturbed in a particular burning section, but prevented from spreading to other areas in KDNR.
- The type of fire e.g. 'cool' or 'hot', surface fire or crown fire could be controlled by choosing the conditions suitable for the kind of fire.
- A fire frequency of 3 to 4 years is recommended depending on rainfall and veld condition.
- The available biomass (kg/ha) and the vegetation condition of each designated section should be measured each year before a decision to burn is taken. If the biomass is less than 2000 kg/ha the area should not be burnt.
- The time (season) of the fire treatment of a specific designated section may vary from September to January. For firebreaks or security or for protection of property, burns are generally in winter.
- The fire intensity should be varied. However, the fire intensity is related to fire frequency because the longer the interval between fires, the greater the chance that the fuel load will be higher.
- Human-ignited fires of areas not prescribed for a specific year should be actively prevented, suppressed or contained to the smallest possible area, especially if that block was burnt the previous year, to prevent the negative effects associated with annual burns, e.g. exposure and overgrazing.

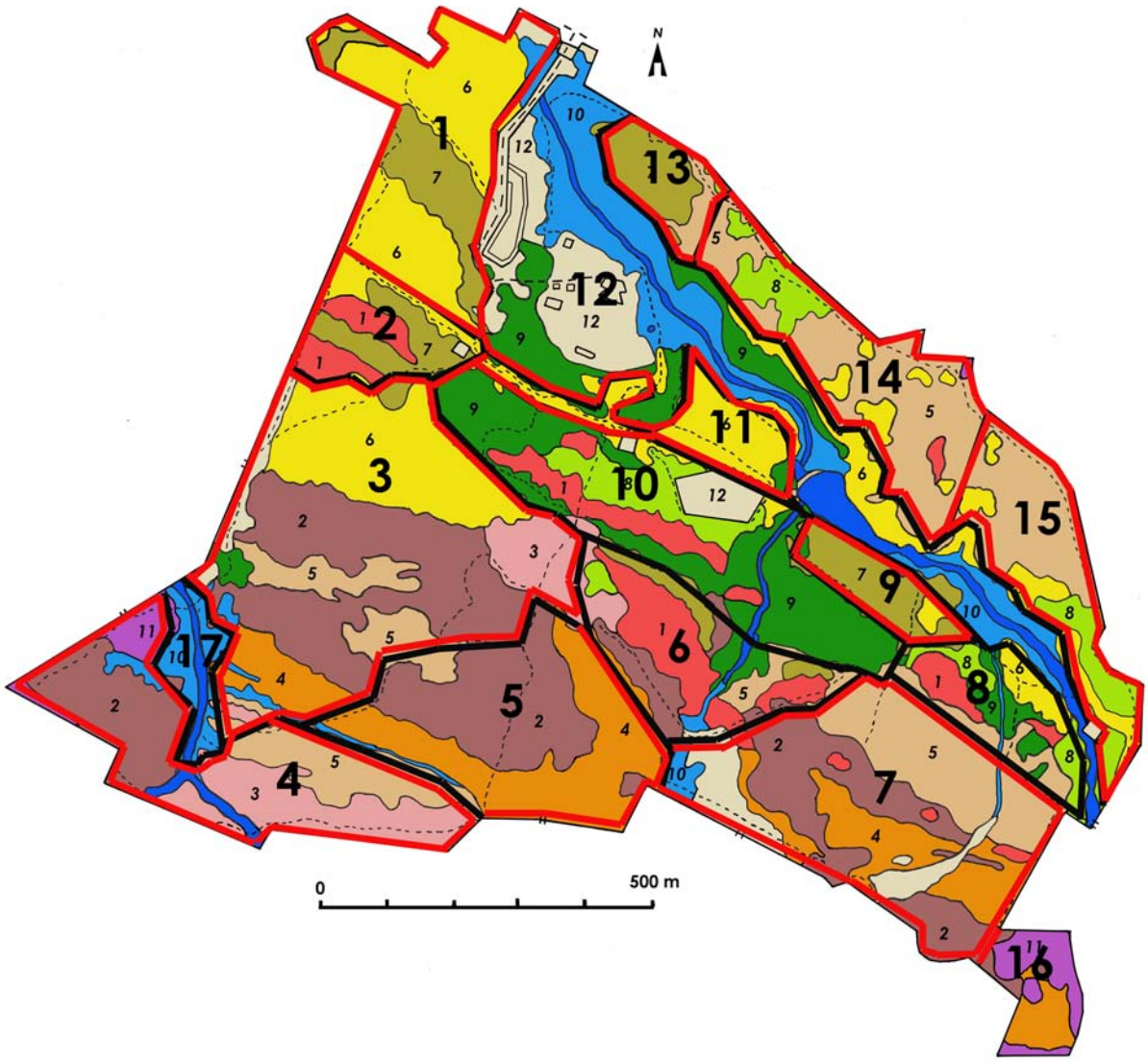

Figure 14. Example of a fire management system based on 17 sections/units in the Kloofendal Nature Reserve. The sections represent relatively homogeneous vegetation types. The units should be separated by firebreaks along roads or trails where possible. Units 6, 8, 10, 12 and 17 should be excluded from burn treatments. Point-ignition must be used within the designated sections.

Figure 15. Impact of fire on the riparian vegetation along the Wilgespruit. The regrowth will develop into an impenetrable thicket.

CHAPTER 9

CONSERVATION OF RARE PLANT SPECIES

Biodiversity is the variability amongst living organisms and the ecological complexes in which these organisms occur. Habitat destruction/transformation and fragmentation through urbanisation is the most serious threat posed to the survival of threatened plants in Gauteng (Pfab & Victor 2002).

- In situ conservation of rare plant species is preferable to ex situ conservation.
- Rare and endemic species/populations must be afforded the maximum protection, as they occur nowhere else in the world.
- It is imperative that ecological processes maintaining Red Data plant populations are maintained.
- It is vital that pollinators active within Red Data plant populations are conserved by managing the habitat to provide nest sites and suitable host and forage plants; protect pollinators from herbicides and pesticides; prevent soil disturbance; and prevent habitat fragmentation.

In situ conservation would involve the following:

- Ensure the persistence of the rare plant populations.
- A suitable buffer zone around the populations needs to be applied.
- Ensure connectivity with adjacent natural vegetation.
- Faciitate/augment natural ecological processes such as fire and herbivory.
- It is usually recommended that access to rare populations be prohibited.
- Monitor and eradicate alien plant invasions that may threaten the rare plant populations.
- It is important that a management plan for the species includes a monitoring plan, particularly to determine whether operational activities are negatively impacting the populations. Such a monitoring program should be structured to collect the following data:
    - Size of population;
    - Age structure and vigour of the population
    - Number of plants;
    - Number of seedlings; and
    - Evidence of plant mortality.

CHAPTER 10

COMMUNITY INVOLVEMENT

9.1 Kloofendal Nature Reserve (Information on Friends of Kloofendal (FroK) website)

The Kloofendal Nature Reserve holds a special place in Johannesburg's 'City of Gold' history. It was the first place on the Witwatersrand where gold was discovered, in 1884, by the Struben brothers. They called the mine the Confidence Reef Mine, but unfortunately the gold ran dry after a single year. The remains of the mine were declared a national monument, now a provincial heritage site, in 1984. The two stamp mills that the Struben brothers used in their search for gold were returned to the reserve in 2009 by the Friends of Kloofendal.

In 1972, Kloofendal was one of the first areas to be set aside by the Johannesburg City Council as a protected wilderness area. A small section of the park, close to the main entrance, was turned into a festival venue with picnic facilities.

9.2 Friend of Kloofendal Nature Conservation

The Friends of Kloofendal (FroK) is an open conservation NGO (NPO No 092-239) that is dedicated to the conservation of the reserve. The Friends of Kloofendal Nature Reserve was founded in 2003. This organisation is a valuable asset to the reserve and close ties between the organisation and Joburg City Parks and Zoo (JCPZ) should be fostered. Some of the activities undertaken by the association include: creation of a website and Facebook page to advertise the reserve and their activities; assist the JCPZ with the management of the reserve e.g. by reporting of sewerage leaks, fires, crime and trying to ensure adherence to public open spaces bylaws; collating information/knowledge on flora, fauna and geology of Kloofendal; documenting the historical assets; establishment, maintenance and mapping of hiking trails; and also undertaking maintenance work such as controlling alien invasive plants and clearing of litter; establishment and running the Environmental Education Centre; and stimulating public awareness by way of lectures and talks, newspaper articles and newsletters.

The aims of the association are listed in BOX 3.

BOX 3, Vision & Objectives of the Friends of Kloofendal Nature Reserve

Vision:
The Friends of Kloofendal envisages the Kloofendal Nature Reserve preserving natural fauna and flora, managed according to sound ecological principles, where many people enjoy the natural environment in safety and peace. The facilities in the amphitheatre area support the nature experience with displays and educational materials, and provide a base for guided nature walks and environmental education presentations as a service for all. The Confidence Reef, site of the first gold mine on the Witwatersrand and the first stampmill in Kloofendal, are part of the Environmental Education Programme in the reserve and amphitheatre area.

Objectives:
- The organisation's main objectives are to preserve, protect and promote the biodiversity and cultural heritage of the Kloofendal Nature Reserve.
- The 50rganization's secondary objectives will be to manage educational programmes and cultural events and to partner with like-minded organisations.

9.3 Hiking trails

The current hiking trails on KDNR cover approximately 5 km. The four trails of various distances are named and indicated on a map of the KDNR (Figure 16). The wetland trail covers primarily the riparian zone and parts of the garden (Table 4), with both the Struben and Dassie trails covering predominantly the bushveld and forest vegetation types. The rocky ridge trail is the longest and covers all communities with the exception of the *Eucalyptus* woodlots (community 11) in the southwestern corner of the reserve.

A high standard of maintenance should be ensured through regular patrolling to ensure that the trails stay in good condition, guard against erosion and defacement of rocks, trees and route markers. The condition of the trails and facilities should be monitored and checked on a regular basis. The opinions of hikers should be asked to increase the quality of a trail. Identification tags on trees could be considered and information on the geology could be provided at strategic sites.

Figure 16. Map indicating the different hiking trails on Kloofendal Nature Reserve.

Table 4. Indication of communities covered by various hiking trails on Kloofendal Nature Reserve

Trail	Community number											
	1	2	3	4	5	6	7	8	9	10	11	12
Wetland										X		X
Struben						X			X	X		
Dassie	X					X	X	X	X	X		
Rocky ridge	X	X	X	X	X	X	X	X	X	X		X

CHAPTER 10

VEGETATION MONITORING PROTOCOL FOR KLOOFENDAL NATURE RESERVE

10.1 Introduction

Ecological monitoring is defined as the purposeful and repeated examination of appropriate parameters to determine the effects of particular management strategies or policies, or the response of systems to changes in the environment. It is the frequent testing of differences between baseline or initial surveys and follow-up surveys. Ecological monitoring emphasizes changes in living organisms and not merely in the physical environment (Hinds 1994).

Monitoring enables managers to periodically assess the state of the system so as to help in decision making in the management process. It is therefore an important aspect of active adaptive management strategies for conservation areas. A monitoring programme can serve as an early warning system to detect changes or trends as a result of management actions or natural events, with the goal to adapt management strategies where necessary. It is now recognised that good management goes beyond implementation and that effective management is integrally linked to well-designed monitoring of evaluation systems (Stem *et al.* 2005). Monitoring also allows managers to develop knowledge over time, which helps to predict how the system will respond to various possible management alternatives (Pollock *et al.* 2002).

Therefore, when management decisions are implemented on a reserve, the possible changes related to these actions should be monitored over time. The veld condition and grazing and browsing capacity of all plant communities need to be monitored regularly when the number of animals increases, which could lead to overgrazing and changes in plant species composition. Monitoring can also be applied to record the recovery of the vegetation in those areas where past mismanagement occurred.

Monitoring methods need to be precise and easily measured in an objective and repeatable manner (Bothma 2010). However, many scientific research methods are expensive, and often require specialised skills or technology. To develop an ecological monitoring programme for the KDNR the monitoring methods had to be scientifically valid, easily implemented and time-efficient. Furthermore, because long-term monitoring data often have to be collected by different people and in some instances even Kloofendal Nature Reserve staff, the measuring techniques have to be simplistic, but still provide valid scientific data for analysis. The monitoring methods should preferably not make use of sophisticated equipment and the duration of the monitoring surveys should be kept as short as is reasonably possible, to avoid surveyor fatigue.

A prerequisite in any monitoring programme is a permanent baseline reference site, which is representative of what is considered necessary to be monitored. The size and shape of the reference site will depend on the method adopted. The frequency of ecological monitoring depends on the rate of the ecological changes that are being measured, and the size of the area.

In a natural environment there are a number of key components of the habitat and the animal spectrum that give a reliable indication of how healthy the whole system is. Apart from the monitoring of the vegetation, some other aspects also need to be monitored regularly to assist in the interpretation of the data. Some aspects, such as climate should be monitored continually, while the productivity of animals should be monitored annually. Others may be measured over longer intervals. These related aspects include the following:

1. Rainfall:

   Rainfall needs to be measured routinely and the location of these rain gauges should be within easy reach, e.g. one at the offices and one in the north at or near the beacon.

2. Wildlife:

   Seasonal distribution, numbers of different types, population growth rate, mortalities, herd composition (age and sex structure) and birth rates.

3. Water provision:

   Location of permanent and artificial surface water, availability and seasonality of water at different locations.

4. Soil erosion:

   Monitoring of erosion spread should be conducted annually. Eroded areas should be rehabilitated and the progress at the sites should be documented with fixed-point photographs.

5. Fire:

   All areas that are burned should be recorded annually on a map of KDNR. The date, weather conditions at the time of the fire, fire intensity and the reasons why the fire occurred should all be noted.

6. Bush control:

Surveys of areas before and after bush control should be done to monitor the impact and/or recovery of the vegetation.

7. Alien plant control:

Surveys of areas before and after alien plant control should be done to monitor the impact and/or recovery of the vegetation.

Vegetation monitoring includes the following components:

1. Herbaceous vegetation:

Condition of the herbaceous layer:
Composition of the plant species;
Frequency (or dominance) of the plant species;
Standing biomass; and
Calculation of veld condition and ecological and economic grazing capacity

2. Woody vegetation:

Condition of the woody layer:
Composition of the plant species;
Structure of the woody layer (canopy volume & density of species); and
Calculation of importance values of species and ecological and economic browsing capacity.

3. Bush encroachment:

Monitoring of the spread or control of bush encroached areas; and
Evaluation will be based on the analysis of the results derived from the monitoring of the woody vegetation.

The results of the vegetation monitoring can be used:

- to assess the herbaceous layer in terms of plant species composition, species frequency, density and/or cover;
- to determine the quality of the herbaceous layer and express it in terms of the veld condition;
- to calculate economic and ecological grazing capacity. This needs to be done annually and the wildlife numbers adjusted accordingly; and
- to evaluate the effects of rainfall, grazing pressure, watering points, erosion control, bush encroachment control, or timing, frequency and intensity of fires.

10.2 Methods

The routine monitoring plots should cover the dominant plant communities in the KDNR as indicated in the vegetation map of the reserve. It is recommended that the vegetation monitoring be done in February/March of each year.

In addition to the routine assessment of the different plant communities, surveys could also be conducted:

- On burnt and unburnt areas of the same plant community to determine the impact of different types of fires on the grass production and species composition.
- On sites where veld reclamation procedures (bush and alien plant control) have been applied.

10.2.1 Herbaceous component

10.2.1.1 Step-point method

The step-point method (100 points)(Mentis 1981) is based on the wheel-point method developed by Tidmarsh & Havenga (1955) and is used to determine the herbaceous plant species composition, species frequency, and ratio of ecological status classes (class 1 to 5). The data are used to calculate the veld condition index (%), which in turn may be used to estimate the ecological and economic grazing capacity of the KDNR. One hundred points are done and at each point the nearest plant species (forb or grass species) is recorded (see Appendix E for a list of grass species occurring in the KDNR, with an indication of the class each one belongs to (see section 2.1.2 below). All non-grassy herbs are recorded as forbs and are therefore not identified and recorded at species level. The reasons for this decision being twofold:

1) the additional time it would take to identify these to species level; and
2) the fact that all forbs are classified as Class 5.

If no plants are found within a 0.5 m radius from the point, it is recorded as bare soil.

$$\text{Frequency (\%)} = \frac{\text{Number of nearest recordings of a species}}{\text{Total number of points (=200)}} \times 100$$

On selected sites where the herbaceous layer is in a poor condition and most of the plants are annual it could be considered to record the annual and perennial grass species separately. In these cases the abundance of annual species might mask the changes occurring in the perennial component.

10.2.1.2 Veld condition assessment

The following approach is based on the method described by Bothma, Van Rooyen & Van

Rooyen (2004). The first step is to calculate the frequencies of the grass species in a community. This indicates the degree of dominance and the distribution of the relevant species. The grasses and forbs are subjectively classified into five ecological classes, based on their perceived grazing value, biomass production and palatability (see Appendix B). The five ecological classes (and their constant multiplier) that are recognised are the following:

Class 1: Valuable and palatable tufted and stoloniferous grass species with a high productivity and high grazing value (multiplier for veld condition: 10)

Class 2: Tufted grass species with an intermediate productivity and moderate grazing value (multiplier for veld condition: 7)

Class 3: Tufted grass species with a high productivity but a low grazing value (multiplier for veld condition: 5)

Class 4: Generally unpalatable and perennial tufted and stoloniferous grass species with an intermediate productivity and a low grazing value (multiplier for veld condition: 4)

Class 5: Unpalatable annual grass and forb species with a low productivity and low grazing value (multiplier for veld condition: 1).

By using these classes, an ecological score is calculated to express veld condition. Theoretically, the maximum ecological score value that can be obtained is 1 000, i.e. if all species present are classified as Class 1 species. The veld condition score is usually expressed as a percentage and indicated as the veld condition index. A veld condition index lower than 40%, usually reflects a low grass cover, high percentages forbs and unpalatable annual grasses, low biomass production and consequently indicates veld in poor condition for grazers. Veld in good to excellent condition should have an index of higher than 60%, with a high grass cover and a high presence of perennial Class 1, Class 2, and some Class 3 species.

To determine the capacity of the plant community to support wild grazing herbivores the following equation should be applied:

$$\text{Grazer Units/100ha} = 0.547 * \{[c + (r - 419) * 0.23] * a * f * (\log_{10} g - 1)^{0.4}\}$$

Where:

c = the range condition index,
r = the mean annual rainfall over the past 2 years in the KDNR (mm)
a = an index of accessibility, i.e. the degree of accessibility of the habitat to plains wildlife on a scale of 0.1-1.0, with 1.0 = fully a accessible,
f = a fire factor on a scale of 0.8-1.0, with 0.8 = recent fire and 1.0 = the absence of fire,
g = the percentage grass cover.

The veld condition score is also used in the Danckwerts equation to calculate grazing capacity.

10.2.1.3 Herbaceous biomass production

The disc pasture meter (Trollope & Potgieter 1986, Dörgeloh 2002, Zambatis *et al.* 2006) is a suitable apparatus to determine the grass production (fuel load) within most vegetation types. It is regarded as a rapid, non-destructive method to determine dry mass yield of grassland. The disc pasture meter consists of a circular flat disc connected to a free moving sleeve on a central rod. The disc is raised to the height of 60 cm. The disc is placed over the required measuring point and released, making sure there are no obstructions, such as dead branches and rocks, as this will prevent the true reading when released. The measurement is taken off the central rod, at the top of the sleeve (Trollope & Potgieter 1986). At each monitoring site 50 readings (disc height in centimetre) are recorded to calculate a mean settling height.

The disc pasture meter ideally has to be calibrated for the area under study. Trollope & Potgieter (1986) and Zambatis *et al*. (2006) described the method of calibration through the use of regressions, comparing the actual dry mass of the plant material to the square root of the disc pasture meter's readings. The equation of Trollope & Potgieter (1986) was re-evaluated by Zambatis *et al*. (2006) and two equations were proposed, one for a mean disc height of ≤26 cm and one for a mean disc height of >26 cm. Until a calibration and an equation have been produced for the KDNR, the following equations may be used to determine the grass biomass (kg/ha):

Equation 1 for a disc height of ≤26 cm:

$$kg.ha^{-1} = [31.7176(0.3218^{1/x})x^{0.2834}]^2$$

where: x = mean disc height in cm of a site

Equation 2 for a disc height of >26 cm:

$$kg.ha^{-1} = [17.3543(0.9893^{x})x^{0.5413}]^2$$

where: x = mean disc height in cm of a site

The biomass value derived by means of the disc pasture meter can be used in the equation by Moore & Odendaal (1987) to estimate the grazing capacity.

10.2.2 Woody component

Monitoring changes in woody species density and cover, or the effect of control of bush encroachment is best done by means of detailed surveys within transects.

10.2.2.1 Transects

Using the BECVOL method transects of 100 m long and 2.5 m wide are used to survey the woody vegetation. GPS coordinates are taken at the beginning and end of each transect. The direction of the survey and on which side of the tape the survey is done should be noted. A metal stake (dropper) is hammered into the soil at the beginning and end points of each transect and spray-painted with red paint. These markers should not be visible from any road. It is recommended that a conspicuous tree be used as the starting point of a transect to make it easier to locate the transect. The approximate positions of the plots (transects) should be indicated on the vegetation map of the KDNR.

A 100 m tape is placed on one side of the transect. Each 5 m section on the transect is recorded separately. All woody plants (trees and shrubs) > 1 m within transects should be identified and for each individual plant, the following measurements must be recorded.

- species name;
- number of stems;
- diameter of main stem (cm);
- maximum height (m);
- maximum canopy diameter parallel to transect (m);
- height of maximum canopy diameter measurement (m);
- height of lowest leaf material (m);
- canopy diameter at lowest leaf material parallel to transect (m);

Seedlings and juveniles of woody species under 1 m in height are identified and counted within each transect and the density expressed as number of plants per hectare.

10.2.2.2 Importance values of woody species

The data collected by means of the transect method are suitable for analysis by the traditional line transect parameters. Measurements are recorded per 5 m sections on the tape i.e. each 5 x 2.5 m section constitutes one unit for a total of 20 units for each transect of 100 m.

The following calculations are made:

$$\text{Relative frequency (\%)} = \frac{\text{Number of units where the species occurred}}{\text{Total number of units}} \times 100$$

$$\text{Relative density (\%)} = \frac{\text{Number of individuals of a species}}{\text{Total number of individuals of all species}} \times 100$$

$$\text{Relative tree height (\%)} = \frac{\text{Total tree height of a species}}{\text{Total tree height of all species}} \times 100$$

$$\text{Relative canopy diameter (\%)} = \frac{\text{Total canopy diameter of a species}}{\text{Total canopy diameter of all species}} \times 100$$

$$\text{Relative dominance (\%)} = \frac{\text{(2 x Rel. canopy diameter) + (Rel. tree height)}}{3}$$

$$\text{Importance value (IV)} = \frac{\text{Rel frequency + Rel density + Rel dominance}}{3}$$

10.2.2.3 Woody biomass production

The BECVOL model (Smit 1996) describes the structure of the woody component quantitatively. The BECVOL program does the following calculations:

Primary calculations (for each individual tree)

Leaf volume; leaf dry mass (DM); and area covered by the tree canopy.

The results of the primary calculations need not be reported on, but are an essential component of the program to derive the secondary calculations.

Secondary calculations (values are calculated per hectare):

PLHA	=	Plants per hectare
LVOL	=	Leaf volume per hectare
LMAS	=	Leaf dry mass (kg) per hectare
LM1.5	=	Leaf dry mass (kg/ha) below a browsing height of 1.5 m
LM2	=	Leaf dry mass (kg/ha) below a browsing height of 2 m
LM5	=	Leaf dry mass (kg/ha) below a browsing height of 5 m

All values are calculated per species and per stand. The browse capacity can be calculated from the dry mass values.

10.2.3 Fixed-point photography

This is an essential component of monitoring. By taking photographs of the vegetation or landscape from the same point at regular intervals and at the same time of year, a visual record is obtained which could at a later stage be subjected to objective analysis (Joubert 1983). The advantages derived from fixed-point photographs include the following:

1 They provide a rapid means for assessing short and medium term trends in the vegetation, and therefore can have predictive value.
2. They provide additional evidence for evaluating and interpreting the impact of various external influences on the vegetation.
3. The method is cheap, easy to apply and provides a permanent record for re-examination when required.

The disadvantage of the method is that it is difficult to quantify the results and therefore not readily subject to statistical analysis. Improvements in computer software have facilitated the analysis and comparison between photographs.

Photographs should be taken each year at the same time of year. For the first few years it would be prudent to take photographs at the same site in both the wet season and the dry season.

Fixed-point photography sites should be established at:

- the sites used for veld condition assessment;
- the woody plant monitoring sites; and
- one photograph should be taken at the starting point of each transect facing the transect line facing away from the sun.
- veld reclamation sites.

Besides the photographs of monitoring plots/transects, photographs should be taken at fixed points throughout the KDNR, e.g. at vantage points or crossroads and in all four wind directions.

10.2.4. Bush encroachment

Encroached areas should be surveyed before and after treatment by mechanical and chemical means. The location of these areas should be mapped and GPS coordinates taken. Follow-up surveys should be done on an annual basis.

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APPENDIX A

GPS coordinates of 25 plots proposed for future monitoring of the grassland communities of KLOOFENDAL NATURE RESERVE

Plot no.	GPS coordinate
3	S26 08 04.8 E27 52 49.8
4	S26 08 06.9 E27 52 46.1
5	S26 08 12.5 E27 52 42.9
6	S26 08 13.6 E27 52 41.0
7	S26 08 15.5 E27 52 39.6
8	S26 08 14.7 E27 52 48.7
9	S26 08 13.3 E27 52 54.1
12	S26 08 12.8 E27 53 00.7
13	S26 08 16.7 E27 53 05.0
16	S26 08 15.2 E27 53 10.4
17	S26 07 52.9 E27 52 42.4
18	S26 07 53.3 E27 52 39.5
20	S26 07 55.6 E27 52 37.3
24	S26 08 08.7 E27 52 24.7
26	S26 08 08.1 E27 52 41.6
31	S26 08 00.3 E27 52 53.0
33	S26 07 58.6 E27 52 59.6
34	S26 08 03.5 E27 53 04.7
37	S26 08 08.3 E27 53 11.5
38	S26 08 09.7 E27 53 14.5
41	S26 08 05.8 E27 53 15.1
42	S26 08 00.9 E27 53 14.0
45	S26 07 53.7 E27 53 04.5
46	S26 07 50.8 E27 53 02.9
48	S26 07 46.6 E27 52 56.4